alloy structures, as represented by the straight line interpolation between the values for the component elements at room temperature. This result follows from our thesis that the liquids are more close-packed than interpolation would predict.

Applications

A considerable body of work is now available on the properties of the metastable phases. The expense of gold accounts for the fact that experiments with gold alloys have not proceeded beyond the laboratory stage. However, the glassy state in metals has attractions for materials technology. The absence of long-range crystal structure implies an absence of grain boundaries and lattice defects which means fewer weak points for corrosive attack. Likewise, the absence of slip mechanisms in metallic glasses would lead one to expect enhanced strength parameters and several papers have appeared on this topic (27). Glassy metals are harder with better wear resistance. Commercial exploitation of the materials is still some way off but continuous production in ribbon and fibre form of base-metal glasses (chiefly iron alloys) has already commenced.

The potential of gold in this field has not been explored in depth, which underlines the fact that gold is underrated as an industrial material in spite of its being indispensable in so many applications. It is hoped that as more is discovered about the metallic glasses, the wealth of theoretical and fundamental data on liquid gold and its alloys will be put to good use in practical applications.

References

1 N. W. Ashcroft and J. Lekner, *Phys. Rev.*, 1966, **145**, (1), 83

2 N. C. Halder and P. Jena, *J. Chem. Phys.*, 1972, **57**, (5), 1830

3 S. P. Isherwood and B. R. Orton, *J. Phys. C.*, 1972, **5**, (21), 2977

4 R. M. Waghorne, V. G. Rivlin and G. I. Williams, *Adv. Phys.*, 1967, **16**, (62), 215

5 R. M. Waghorne, V. G. Rivlin and G. I. Williams, *J. Phys. F: Metal Phys.*, 1976, **6**, (2), 147

6 J. R. Wilson, *Metall. Rev.*, 1965, **10**, (40), 381

7 A. R. Ubbelohde, "Melting and Crystal Structure", Clarendon Press, Oxford, 1965, p. 170 et seq.

8 V. M. Glazov, S. N. Chizhevskaya and N. N. Glagoleva, "Liquid Semiconductors", Plenum Press, New York, 1969, p. 323

9 S. P. Isherwood, B. R. Orton and A. Mănăilă, *J. Non-Cryst. Solids*, 1972, **8**, 691

10 Y. Waseda and K. Suzuki, *Z. Physik*, 1975, **B20**, (4), 339

11 W. Hume-Rothery and E. Anderson, *Phil. Mag.*, 1960, **5**, (52), 383

12 H. S. Chen and D. Turnbull, *J. Appl. Phys.*, 1967, **38**, (9), 3646

13 D. Turnbull, *J. Phys. (Paris), Colloq.*, 1974, **35**, Pt. **4**, 1

14 R. P. Anantatmula, A. A. Johnson, S. P. Gupta and R. J. Horylev, *J. Electron. Mater.*, 1975, **4**, (3), 445

15 V. G. Rivlin, Fulmer Research Institute, Progress Report, R513/2/January 1975

16 W. Klement, R. H. Willens and P. Duwez, *Nature*, 1960, **187**, (4740), 869

17 H. S. Chen and C. E. Miller, *Rev. Sci. Instr.*, 1970, **41**, (8), 1237

18 W. Klement, *Trans. AIME*, 1963, **227**, 965

19 B. C. Giessen, *Z. Metallkunde*, 1968, **59**, (10), 805

20 C. Suryanarayana and T. R. Anantharaman, *Mater. Sci. Engng.*, 1974, **13**, (2), 73

21 T. R. Anantharaman, H.-L. Luo and W. Klement, *Nature*, 1966, **210**, (5040), 1040

22 M. G. Scott, *Mater. Sci. Engng.*, 1975, **18**, (2), 279

23 A. K. Jena, B. C. Giessen, M. B. Bever and N. J. Grant, *Acta Metall.*, 1968, **16**, (8), 1047

24 C. C. Tsuei, H.-C. Yen and P. Duwez, *Phys. Lett.*, 1971, **34A**, (2), 80

25 H. Jones, *Rep. Prog. Phys.*, 1973, **36**, (11), 1425

26 H. Jones and C. Suryanarayana, *J. Mater. Sci.*, 1973, **8**, (5), 705

27 C. A. Pampillo, *J. Mater. Sci.*, 1975, **10**, (7), 1194

Characteristics of Gold-Copper-Cadmium Electrodeposits

Ternary gold–copper–cadmium electrodeposits from an alkaline cyanide solution have been established for some years and have found applications mainly in the decorative field. A typical composition is 75 per cent gold with 15 per cent copper and 10 per cent cadmium, but minor changes in composition can affect the characteristics of the deposits and considerable care is required in controlling the electrolyte.

One of the advantages of this alloy deposit is of course the economy in gold, but for industrial or electronic applications this is outweighed by the high contact resistances developed in use. None the less, an investigation of its characteristics by comparison with those of a high purity gold and a 99.8 per cent gold 0.2 per cent cobalt deposit, reported by J.-J. Robert of Lea-Ronal France (*Galvano-Organo*, 1976, (461), 33–36 and (462), 114–117) adds to our knowledge.

Naturally the Vickers hardness of the ternary deposit is significantly greater than either of the straight golds tested, while its resistances to wear was also found to be superior. Ductility tests, carried out by two methods—one on plated copper wires bent over small mandrels and the other by spiralling plated strips—showed distinct improvements with the ternary alloy deposit.

But in the vital matter of contact resistance the results obtained by Robert—and supplemented by those of others who have studied this electrolyte—confirm the unsuitability of this type of deposit for applications in which minimal values are essential. Measurements with a milliohmeter at room temperature and with increasing contact pressures showed substantially higher readings with the ternary deposit. Specimens subjected to a temperature of 100°C in air for increasing lengths of time also showed an appreciable rise in contact resistances after 200 hours, while the pure gold and the cobalt–gold gave much smaller increases in contact resistance. L. B. H.